The role of climate change in mass extinctions: Using stromatolites to constrain temperatures during times of biotic crisis

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Background: The End-Triassic Mass Extinction is thought to be associated with environmental change caused by the emplacement of the Central Atlantic Magmatic Providence. For this study, we examined Late Triassic stromatolites from the Cotham Member of the Lilstock Formation (Bristol, UK) to study climate change across the End-Triassic extinction event.

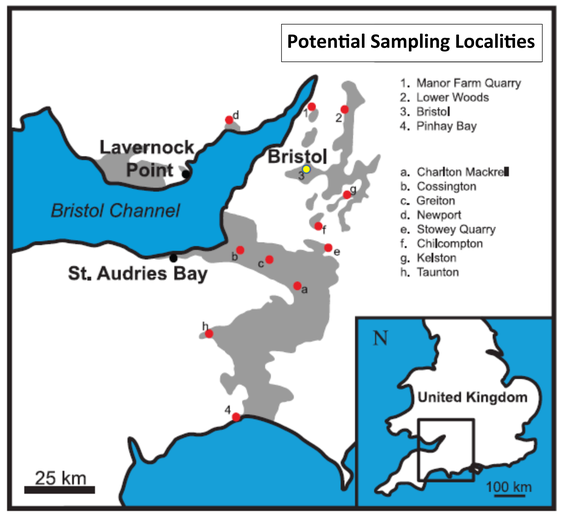


Figure 1: Map detailing Triassic-Jurassic deposits in the UK (grey) Red dots are localities containing the Cotham Marble. Our research site (Bristol) is highlighted in yellow (after Ibarra et al., 2013)

Figure 2: Paleoreconstruction of the Tethys Sea during the end-Triassic. Sample site is indicated by the red circle and star.

Figure 3: Outcrop photo of the Cotham Marble from the Lower Woods Nature Reserve. Stromatolites are easily identified based on morphology in comparison to the surrounding rock. The stromatolites are the bottom bed on the outcrop with the bumpy texture.

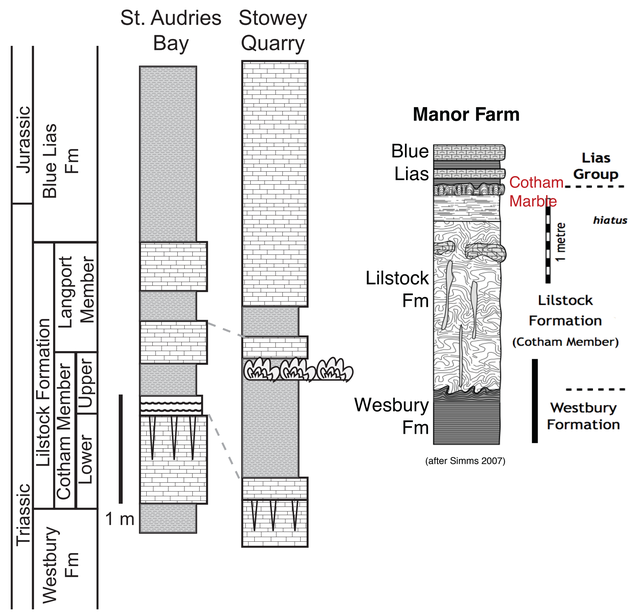


Figure 4: Regional stratigraphy for the Lilstock Formation. Samples were collected from Bristol and correlated to the section from the Stowey Quarry (Figure 1).

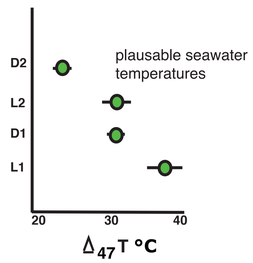
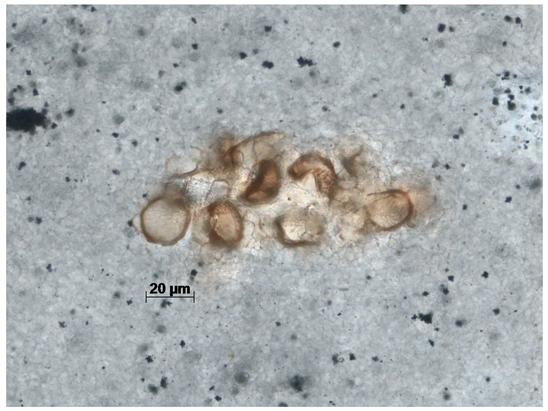


Figure 5: Cotham stromatolite showing the alternating pattern of laminated and dendritic layers, starting with the first laminated layer on bottom and ending with the second dendritic layer on top. Δ_{47} temperatures are plausible for seawater

Table 1: Stable isotope data for Cotham stromatolites from Triassic-Jurassic interval

Sample	Facies	δ^{13}C Mineral (‰ VPDB)	δ^{18}O Mineral (‰ VPDB)	Δ_{47} ETF	Δ47 T°C	1se T error	Water δ18O (‰ VSMOW)	Prop. Error
TJCMBD2	Dendritic 2	0.435	-1.5	0.723	22.5	0.8	0.3	0.5
TJCMBD2rerun		0.405	-1.5	0.707	25.8	1.2	1.1	0.5
TJCMBL2	Laminated 2	-0.709	-2.1	0.678	32.0	1.2	1.6	0.7
TJCMBL2		-0.715	-2.1	0.701	27.1	1.2	0.7	0.8
TJCMBD1	Dendritic 1	0.141	-0.7	0.678	32.1	1.8	3.1	1.1
TJCMBD1		0.120	-0.8	0.695	28.3	0.9	2.3	0.5
TJCMBL1	Laminated 1	-0.087	-1.1	0.656	37.0	1.9	3.6	1.1
TJCMBL1		-0.054	-1.2	0.659	36.4	1.1	3.4	0.7

Results: Late-Triassic Cotham stromatolites yielded temperatures between 22.5 and 37.0 °C. The average temperature calculated for the Triassic-Jurassic stromatolites was 29.3°C. Stromatolites show a cooling trend over the course of accretion. Reconstructed water isotope values are consistent with evaporation-dominated, low latitude marine realms.



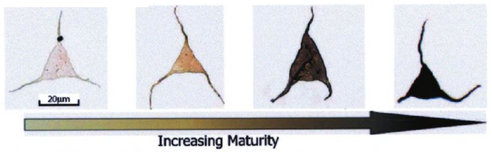


Figure 6: Assessment of thermal maturity of the Cotham Marble stromatolties. Putative *Tasmanities*, an algal spore common in times of biotic crisis, show low maturity on the thermal alteration index, indicating that these samples are not significantly diagenetically altered

Discussion: The data from Cotham stromatolites yield physically plausible ocean temperatures. These stromatolites present evidence for increases in oceanic temperatures coincident with the global climate change during the end-Triassic extinction. These preliminary results may indicate that ocean temperatures were increasing locally due to the larger scale global climate change associated with the eruption and sea floor spreading occurring at the Central Atlantic Magmatic Providence. These temperatures are plausible as the stromatolites were grown in a shallow water environment as indicated on the map. Reconstructed water isotope values are consistent with enhanced evaporation relative to precipitation during a period of greenhouse gas-induced warming. Further study of stromatolites across the Triassic-Jurassic boundary could be used to create a better understanding of the changes in climate that occurred, and provide insights into what may have driven the mass extinction.

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